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ABSTRACT

Students in 6 Biology classes for nonmajors (n=349) participated in this study of the effectiveness of cooperative learning as an instructional strategy. One lecture class integrated daily cooperative group learning strategies throughout the semester; the other five classes continued direct lecture instructional practices. The data collected to determine biological literacy were obtained using the Biology Self-Efficacy Scale (BSES) (J. Baldwin, D. Ebert-May, and D. Burns, 1999) and the Texas high school Biology End-of-Course (BECE) examination for spring 2001 administered in a pretest and posttest design. Data on student achievement came from the final course grade as reported by the lecture instructor. Differential means were analyzed with a one-way analysis of variance. Comparing the cooperative with the direct lecture classes shows a significant difference between the differential means of BSES factor 3, application of biological concepts, and BECE overall knowledge. There was no significant difference between the cooperative class and the direct lecture classes BSES factor 1, methods of biology and factor 2, generalization to other sciences, or BECE process and content questions. There was no significant difference in academic achievement. Although the cooperative lecture class reported greater confidence in applying biology to other areas and overall biology knowledge, this study's results were not consistent with primary through postsecondary research related to cooperative learning, biological literacy, and academic achievement. (Contains 32 references.) (Author/SLD)

The Effectiveness of Cooperative Learning as a Instructional Strategy to Increase Biological Literacy and Academic Achievement in a Large, Non-majors College Biology Class

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The Effectiveness of Cooperative Learning as an Instructional Strategy to Increase Biological Literacy and Academic Achievement in a Large, Non-majors College Biology Class

Abstract

Cooperative learning may be defined as an active learning strategy in which students work together to create their knowledge interdependently to maximize their own and each other's learning (Aronson, Blaney, Stephens, Sikes, & Snapp, 1978; Johnson & Johnson, 1978; Kagan, 1988; Sharan & Sharan, 1976; Slavin, 1977). Six non-major's biology lecture classes (N=349) at a moderate sized southern university in the Fall 2002 semester participated in the study. One lecture class integrated daily cooperative group learning strategies throughout the semester; the other five classes were a continuum of direct lecture instructional practices. The data collected to ascertain biological literacy was obtained using the Biology Self-Efficacy Scale (BSES) and the Texas high school Biology-End-of-Course Exam (BECE, Spring 2001) administered in a pre- and posttest design. The data on student achievement was determined by the final course grade as reported by the lecture instructor. Differential means were analyzed with a One-Way ANOVA. Comparing the cooperative with the direct lecture classes, there was a significant difference between the differential means of BSES Factor 3, application of biological concepts (F (5,343) = 3.737, $p < .01$), and BECE overall knowledge (F (5,343) = 12.455, $p < .0005$). There was no significant difference between the cooperative class and the direct lecture classes BSES Factor 1, methods of biology (F (5,343) =1.953, $p > .05$), and Factor 2, generalization to other sciences (F (5,343) = 3.351, $p < .01$), or BECE process (F (5,343) = 1.071, $p > .05$) and content (F (5,343) = 1.156, $p > .05$) questions. There was no significant difference in academic achievement (F (5,343) = 1.592, $p > .05$). Although the cooperative lecture class reported greater confidence in applying biology to other areas and overall biology knowledge, this study's results were not consistent with primary through postsecondary research related to cooperative learning, biological literacy, and academic achievement.

Introduction

This study examined the effectiveness of cooperative learning as an instructional strategy in a large, non-majors biology class as a means to enhance biological literacy and increase academic achievement in biology. More is known about the efficacy of cooperative learning than lecturing, departmentalization, and the use of instructional technology; however higher education faculty continue to teach through the traditional lecture method (Johnson, Johnson, & Smith, 1991; Johnson, Johnson, & Stanne, 2000). A study by Allard and Barman (1994) indicated that many college students are less sophisticated in their thinking than previously assumed and benefit greatly from active learning strategies. The goal of science education is to develop scientifically literate individuals who can sort sense from nonsense and to cultivate skills of critical thinking and problem solving (AAAS, 1989; Bybee, 1997; NRC,1996). The teaching of these skills does not depend on what is taught, but how it is taught, through student discussions, verbalization of metacognition, and emphasis on problem-solving procedures. Scientific literacy is much more than the recall of facts, and includes the process of science, in addition to attitudes and values that extend from the nature of science itself. Some researchers have argued that perceived confidence in carrying out a given task, such as mastering biological content and processes, will strongly predict the future acquisition of skills and behavior, such as motivation to pursue biology education (Ebert-May, Brewer, & Allred, 1997). The focus of this study was to determine if cooperative learning increased college students' academic achievement and self-reported confidence in understanding biology and the relevance to their lives.

Review of Literature

A meta-analysis by Slavin (1995) showed an extensive body of literature on cooperative learning as it relates to positive affective and cognitive outcomes, primarily in K-12 settings. Research in primary and secondary education demonstrated that cooperative learning produces higher achievement, more positive relationships among students, and healthier psychological adjustment than do competitive or individualistic experiences with effect sizes = 0.67 and 0.64, respectively (Johnson & Johnson, 1989, 1998; Johnson, Johnson, & Smith, 1991; Johnson, Johnson, & Stanne, 2000; Slavin,

1995). When only college and adult studies were analyzed, cooperative learning produced higher achievement than did competitive (oppositional interaction between students) or individualistic (no interaction between students) learning with effect sizes = 0.59 and 0.62, respectively (Johnson & Johnson, 1987, 1989; Johnson, Johnson, & Smith, 1991). A meta-analysis of the effects of small group learning from 39 studies in postsecondary science, math, engineering, and technology classes reported students who learned in cooperative groups demonstrated greater achievement (effect size = .51) than students who were not exposed to cooperative methods (Springer, Stanne, & Donovan, 1999).

There are multiple pedagogical situations in which college biology instructors are using groups to maximize the learning for students in lecture and laboratory classes. In college biology studies that statistically examined achievement, less than half (37.5%) noted a significant difference (Hufford, 1991; Klionsky, 1998; Lord,1994; Posner & Marksein, 1994; Schamel & Ayers, 1992; Temperly, 1994; Trauwein, Rack, & Hillman, 1996). Positive student perceptions of cooperative learning were observed in 70% of the studies reviewed (Colosi & Zales, 1998; Ebert-May, Brewer, & Allred, 1997; Hall, 1992; Goodwin, Miller, & Cheatham, 1991; Janners, 1988; Klionsky, 1998, Lord, 1994, Posner & Marksein, 1994; Schamel & Ayers, 1992; Temperly, 1994; Watson & Marshall, 1995). Studies that researched the effect of cooperative learning on achievement and minorities, found positive correlations and increased student retention in the biology class or in the biological sciences as a major (Hufford, 1991; Posner & Marksein, 1994). Large classes were also effectively using cooperative learning groups in 88% of the studies where class size exceeded 75 students per class (Ebert-May, Brewer, & Allred, 1997; Eisen, 1998; Hufford, 1991; Klionsky, 1998; Lord, 1994; Posner & Marksein, 1994).

Although over 900 experimental and correlational studies have examined cooperative learning, less than one-fourth were at the college-level and only a small percentage of those studies were in the sciences. A large meta-analysis of 37 studies (Springer, Stanne, & Donovan, 1999) related to cooperative learning and achievement in postsecondary science, math, and technology included only two studies in biology, the majority of the studies were in mathematics.

The Springer, Stanne, and Donovan study (1999) supported a survey by Anthony (1994) that reported that those in the sciences are least likely to use cooperative teaching strategies and rely primarily on the direct lecture approach to teaching. Unfortunately, in the traditional lecture environment, the student is a spectator in the classroom and not actively but passively involved in their learning. Another factor that creates passive student involvement in colleges are large classes. A study by Allen and Niss (1990) showed the large lecture hall is detrimental to teaching effectiveness. A large class puts severe restrictions on the possibility of interaction between instructor and student, and could inhibit the cross fertilization of ideas and integration of knowledge (Knapper, 1987). One factor which professors have some control over is the classroom environment and the integration of a variety of active learning methodologies.

The review of the literature related to college biology classes and cooperative learning does not show the same positive outcomes and correlations as described in the primary and secondary literature and college-related literature. An examination of cooperative learning as an effective instructional strategy in large college biology classes as it relates to biological literacy is only supported in one study (Ebert-May, Brewer, & Allred, 1997). The limited number of studies in college biology classes and the contradiction in the literature of academic outcomes suggests a need for more research in this area.

Methods

The purpose of this study was to determine if the use of formal cooperative learning groups, a type of active learning strategy, increases biological literacy and academic achievement in a large, introductory college biology class. This study attempted to answer the following questions:

1. What is the effectiveness of cooperative learning as an instructional strategy in large college biology lecture classes on biological literacy?
2. What is the effectiveness of cooperative learning as an instructional strategy in large college biology lecture classes on student academic achievement in biology?

Approximately 350 students, comprising 6 classes and 20 laboratory sections, attending the non-majors biology class at a moderate sized university in the mid south, participated in the study. The class rank of the sample population consisted of 57% freshmen, 31% sophomores, 8% juniors, and 4% seniors. Demographically the sample population consisted of 49% females and 51% males. Ethnically 85% were Caucasian, 12% were African-American, and 3% were classified as Other. The six lecture classes that participated in this study were selected based on size (approximately larger than 75 students per class) and self-reported instructional style as determined by the instructor. Five of the classes utilized a continuum of direct lecture methodology and one class utilized formal cooperative learning groups. Of the five direct lecture classes, three had enrollments of approximately 75 students and two had enrollments of approximately 100 students. The cooperative lecture class had an enrollment of approximately 75 students and was the designated experimental lecture class. Cooperative learning instructional strategies were integrated into every lecture in the experimental class.

To examine the effect of cooperative learning upon biological literacy and academic achievement, subjects in the experimental class were assigned to formal cooperative groups that were academically heterogeneously designed (Johnson, Johnson, & Smith, 1991; Kagan, 1994; Slavin, 1995). Each group had one high- ($\geq$ 90 class average), one low- ($\leq$ 59 class average), and two middle- (70 – 89 class average) achieving students. The first class exam, quizzes, and writing assignments determined the grade that was then used for group placement. After a brief lecture that introduced the key concepts for that class, groups convened to cooperatively complete a task or assignment aligned to that day's lecture. Group assignments and projects compiled points that had the weighted percentage of one lecture exam.

Data collected to ascertain biological literacy was obtained using the Biology Self-Efficacy Scale (BSES) and the Biology-End-of-Course Exam (BECE) administered in a pre- and posttest design. The data on student achievement was determined by the final course grade as reported by the lecture instructor.

The BSES is a 23-item instrument that was developed and validated by Baldwin, Ebert-May, and Burns (1999) and is designed to determine students' self-reported confidence in understanding and using biology in their lives. Students responded to how

confident they would be in carrying about a given task on a five-point Likert scale ranging from totally confident, very confident, fairly confident, only a little confident, and not at all confident. Factor analysis supports the contention that BSES is a multidimensional construct consisting of at least three dimensions: methods of biology; generalizations to other biology/science courses and analyzing data; and application of biological concepts and skills. Factor 1 represents a students' perceived sense of confidence in using analytical skills to conduct experiments and writing or critiquing his or her idea through laboratory reports. Factor 2 relates to perceived confidence in generalizing skills learned through the biology course to other science courses or using a scientific approach to solve problems. Factor 3 identifies a student's perceived confidence in his or her ability to apply biological concepts and skills to daily life. These three factors are consistent with broad definitions of scientific literacy (AAAS,1989; Bybee, 1997; National Research Council, 1996). The BECE is a 42-item multiple-choice instrument developed for the Texas Educational Agency that assesses students' mastery of nine objectives in the area of high school biology. The variables produced by this instrument were pre- and posttest scores. The pretest scores were used to determine the level of biological knowledge at the initiation of the class. The posttest scores determined the extent of the knowledge gained during the 16-week class. The pre- and posttest knowledge scores were determined by percentage of correctly answered items, ranging between 0 and 100. Pre- and posttest content and process questions correctly answered were also examined.

Results

Six lecture classes (N=349) participated in the study; one lecture class utilized cooperative learning strategies (n=51) and five lecture classes utilized a continuum of direct lecture methods (n=298). Letters A through E identified direct lecture sections, and the letter F identified the cooperative lecture section. Differential means were compared from the Biology Self-Efficacy Scale (BSES) and a high school Biology End-of-Course Exam (BECE) to measure biological literacy. Academic achievement was determined by comparing students' final course grade as generated by each lecture instructor.

The differences between the means of pretest and posttest variables were determined and compared for significant differences between and within the six large lecture classes. The six differential mean variables were: (1) BSES biological literacy analysis of biological concepts – Factor 1; (2) BSES biological literacy generalization to other sciences - Factor 2; (3) BSES biological literacy application – Factor 3; (4) BECE knowledge test percentile grade; (5) BECE process questions answered correctly; (6) BECE content questions answered correctly. The dependent variable of final letter grade was used to determine the difference in achievement between direct lecture classes and the cooperative class.

Using descriptive statistics and analysis of variance, the null hypothesis of student perception and confidence in analyzing biological methods (Factor 1) in the cooperative class verses the direct lecture class was retained ($\underline{F}$ (5,343) =1.953, $\underline{p}$ > .05). Although lecture D had the greatest difference in means for BSES Factor 1, cooperative lecture F had the second greatest difference in means. These students positively perceived themselves as confident at analyzing biological methods by the end of the course. Direct lecture sections B and E had the lowest difference in means that indicates that the students in these sections had the least perceived confidence in analyzing biological methods.

Using descriptive statistics and analysis of variance, the null hypothesis of student perception and confidence in generalizing biology knowledge to other sciences (Factor 2) in cooperative verses direct lecture classes was retained ($\underline{F}$ (5,343) = 3.351, $\underline{p}$ < .01). Although significant, the highest positive difference was with lecture C; cooperative lecture F had the second highest positive difference in means. Again, lecture B and E had the lowest difference in means that could infer that these students gained the least confidence in their perception to generalize biology to other sciences. On the other hand, direct lecture C and cooperative lecture F's sections with higher positive differences in BSES Factor 2, may be more confident in their perceived ability to generalize to other sciences.

Using descriptive statistics and analysis of variance, the null hypothesis of perceived confidence in applying biological concepts (Factor 3) in cooperative verses direct lecture classes was rejected. Cooperative lecture F had the greatest difference

in means for BSES Factor 3 (F (5,343) = 3.737, $p < .01$), this could suggest that cooperative learning teams increased student perception of application of biological concepts. Direct lectures E and B again had the least difference in means in perceived confidence in biological application.

Using descriptive statistics and analysis of variance, the null hypothesis of perceived confidence in overall student knowledge on the BECE in cooperative and direct lecture classes was rejected (F (5,343) = 12.455, $p < .0005$). Cooperative lecture F had the greatest difference in means for the BECE, this could suggest that cooperative teams increased student knowledge. Lecture E had a very high negative value that suggests that students in this lecture class lost overall knowledge during the semester.

Using descriptive statistics and analysis of variance, the null hypothesis of the relationship to biological literacy and student process skills on the BECE in the cooperative class verses the direct lecture class was retained (F (5,343) = 1.071, $p > .05$). Cooperative lecture F had the greatest difference in means that suggests the cooperative teams increased in biology process skills during the semester of biology. Lecture D had the lowest difference in means that suggests these students learned fewer process skills during the course.

Using descriptive statistics and analysis of variance, the null hypothesis of the relationship to biological literacy and student content skills on the BECE in the cooperative class verses the direct lecture class was retained (F (5,343) = 1.156, $p > .05$). All the classes had a negative difference in means, with lecture E having the highest negative difference. The cooperative lecture F had the second highest negative difference in means and suggests that even though students gained in all other areas, they lost content skills in the duration of the course. There was certain content information they knew going into the class that was not retained in all the lecture sections.

Using descriptive statistics and analysis of variance, the null hypothesis of the relationship of academic achievement in the cooperative class verses the direct lecture class was retained (F (5,343) = 1.592, $p > .05$). A comparison of the final letter grade as determined by each instructor was highest for lecture E. This suggests that even

though these students had the lowest perceived change in confidence in biological methods, generalizations, and application, plus the highest negative difference in means regarding biological content, they earned as a lecture section the highest average final grade. The second highest average was the cooperative lecture F; this suggests that cooperative students had positive gains in perceived confidence in biological methods, generalizations, application, and overall biological knowledge as well as process skills.

Conclusion

One purpose of this research study was to determine the effectiveness of cooperative learning as an instructional strategy to enhance biological literacy as measured by the BSES and the BECE instruments in large college biology classes. The BSES instrument measured student-reported confidence in analyzing biological methods (Factor 1), generalizing biology to other sciences (Factor 2), and applying biological concepts (Factor 3). The other dependent measure of biological literacy was a standardized end-of-course high school biology exam (BECE). Questions were identified for analysis as either process-oriented, which assessed student ability to interpret information from a graph, or content-oriented which probed student recall of information. These components represent dimensions of scientific literacy that have commonly been described in the literature (AAAS, 1989; Bybee, 1997; National Research Council, 1996).

The results from this study marginally support cooperative learning as an instructional strategy to increase biological literacy in large college biology classes. Although there was a significant difference in application of biological concepts (Factor 3) and overall biological knowledge on the BECE, there was no significant difference in analyzing biological methods (Factor 1) and generalizing biology to other sciences (Factor 2), or BECE process and content questions. This study also marginally supports the findings of a Northern Arizona University study of large introductory college biology classes (Ebert-May, Brewer, & Allred,1997) that also examined biological literacy and cooperative strategies. Students in the active-learning lecture format had significantly higher analysis (Factor 1), generalization (Factor 2), and application (Factor 3) (F (3, 274), p<.05) and process scores (F(1, 336), p<.005).

The second purpose of this study was to examine the instructional effect of cooperative learning on academic achievement as determined by final course grade. Each lecture section generated a final course grade based on the individual lecture instructor's criteria for the course. There was no significant difference in academic achievement and cooperative learning verses direct lecture methods. This could suggest that the extra time involved with group learning activities does not have a negative impact on academic achievement. This data supports the research findings of more than half of the college biology studies reviewed that statistically examined achievement.

This research study is consistent with research findings of positive student attitudes toward cooperative groups and biology in general. Nearly 93% of the students in the cooperative lecture F reported the group was sometimes/almost always helpful to understanding biology content in the class. A few other positive comments were: (1) that is was nice to get to know others in such a large class and hear other opinions; (2) that it was so helpful to have the opportunity to work with the lecture material in a manner that applies the content, and; (3) that it was great to not sit and be 'talked to' the entire class.

Limitations

The following limitations have been acknowledged in regard to this study:

1. The sample for this study included only students enrolled in the non-majors biology course in the Fall 2001 semester at a moderate-sized public university in the mid south; results of this study to other populations is restricted by the type of sample and populations which are similar demographically.
2. This study only examined biological literacy and academic outcomes that were measurable in a group setting with paper and pencil test forms.

Suggestions for Further Research

Based on the results of this study, more research is required to examine several questions related to this study. Some of these include the following:

1. Cooperative learning may be a powerful recruitment tool for a national decline in declared science majors. Based on positive student perceptions of

cooperative learning, could implementation of cooperative groups in non-majors introductory classes increase the number of students that choose a major or career related to biology?

2. Would cooperative learning strategies integrated into direct lecture classes on a smaller scale (weekly teams instead of every class) produce the same positive biological literacy perceptions?
3. If students are placed in the same formal cooperative learning group for lecture and lab classes will there be a significant difference in biological literacy perception and academic achievement?
4. What is the relationship between cooperative learning teams in biology lecture classes and student evaluations of lecture instructors?
5. What is the relationship between teacher efficacy and student efficacy? Does this relationship predict achievement or biological literacy perceptions in different settings with different types of biology courses?

This study gave students in cooperative lecture F an opportunity to relate to and interact with the topics covered in the biology class. Students developed a sense of belonging and community, and by effectively communicating with each other, broke the chain of monotony in their college life science experience. The data from this study showed a marginal positive effect of cooperative learning groups on biological literacy and academic achievement, but student responses clearly indicated a positive experience. Students need to be given as many opportunities as possible to be interactively engaged with their course work. Without these opportunities, it highly unlikely that they will remember or even be able to work with course content after they leave the class. If one considers that most non-major college students will only take one class in biology in their college career, the quality of the learning experience becomes more essential if the aim is a biologically literate citizen. As we move into the twenty-first century with issues such as cloning, eugenics, and biotechnology confronting our intellectual and emotional psyche, a biologically literate individual will be better prepared for the journey.

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